

# Elongation at Break

Elongation at Break, also known as fracture strain or tensile elongation at break, is the **ratio between increased length and initial length after breakage** of the tested specimen at a controlled temperature. It is related to the ability of a plastic specimen to resist changes of shape without cracking.

The elongation is calculated as the relative increase in length.

$$\text{Elongation} = \varepsilon = (\Delta L/L) \times 100$$

Where:

- »  $\Delta L$ : Final Length
- » L: Initial Length



Elongation at Break is **measured in %** (% of elongation vs. initial length at which failure occurs).

The maximum elongation i.e. at break,  $\epsilon_{max}$  is also called “**strain to failure**”.

- Ultimate elongation values of several hundred percent are common for *elastomers and film/packaging polyolefins*.
- Rigid plastics, especially *fiber reinforced* ones, often exhibit values under 5%.
- *Fibers* have a low elongation-to-break and *elastomers* have a high elongation-to-break

***The combination of high ultimate tensile strength and high elongation leads to materials of high toughness.***

Elongation at Break measures how much bending and shaping a material can withstand without breaking. The measured elongation at break values are an indication of the ductility of a polymer.

Elongation at break is important in components that absorb energy by plastic deformation. High elongation at break is important for plastic hinges.

**Applications include:**

- » Define ductility of polymers

- » Important for energy absorbing materials by plastic deformation
- » Screen materials for use as plastic hinges

***Check out more on Elongation at Break:***

- » **Elongation at Break Values of Several Plastics**
- » **How to Calculate the Elongation at Break of Plastic**
- » **Factors Affecting Elongation at Break**

### **How to Measure Elongation at Break?**

Tensile tests measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point.

In general, “tensile test methods” are applied measure elongation at break of materials. The common methods used are:

- ASTM D638 - Standard Test Method for Tensile Properties of Plastics
- ISO 527-1:2012 - Determination of tensile properties. General principles

*Ofcourse there exist several other methods as well as listed below, but they are not discussed here.*

### **ASTM D638 and ISO 527 test methods**

ASTM D638 and ISO 527 test methods cover the determination of the tensile properties of plastics and plastic composites under defined conditions in the form of standard dumbbell-shaped test specimens. The defined conditions can range from pretreatment, temperature, humidity, to testing machine speed.

The methods are used to investigate the tensile behavior of the test specimens.

And, the following calculations can be made from tensile test results:

Tensile strength (at yield and at break)

- **Tensile modulus**
- Strain
- Elongation and percent elongation at yield
- Elongation and percent elongation at break

For ASTM D638 the test speed is determined by the material specification. For ISO 527 the test speed is typically 5 or 50mm/min for measuring strength and elongation and 1mm/min for measuring modulus.

An extensometer is used to determine elongation and tensile modulus.

## Factors Affecting Elongation at Break

### Velocity of Testing

Slow testing allows for polymer relaxation and higher elongation at break values

### Orientation Level

Fibers that are less oriented tend to exhibit greater degrees of elongation at break

### Temperature

In general, the elongation at break increases with an increase in temperature

### Filler Content

The elongation at break of composites decreases with an increase in the filler content

## Elongation at Break Values of Several Plastics

Polymer Name	Min Value (%)	Max Value (%)
ABS - Acrylonitrile Butadiene Styrene	10.0	50.0
ABS Flame Retardant	2.0	80.0
ABS High Heat	2.0	100.0
ABS High Impact	2.0	100.0
ABS/PC Blend - Acrylonitrile Butadiene Styrene/Polycarbonate Blend	60.0	85.0
ABS/PC Blend 20% Glass Fiber	1.90	2.10
ABS/PC Flame Retardant	50.0	90.0
ASA - Acrylonitrile Styrene Acrylate	15.0	40.0

ASA/PC Blend - Acrylonitrile Styrene Acrylate/Polycarbonate Blend	25.0	50.0
ASA/PVC Blend - Acrylonitrile Styrene Acrylate/Polyvinyl Chloride Blend	40.00	70.00
CA - Cellulose Acetate	16.00	53.00
CAB - Cellulose Acetate Butyrate	40.00	90.00
Cellulose Diacetate-Pearlescent Films	25.00	45.00
Cellulose Diacetate-Gloss Film	25.00	45.00
Cellulose Diacetate-Integuard Films	5.00	15.00
Cellulose Diacetate-Matt Film	25.00	45.00
Cellulose Diacetate-Window Patch Film (Food Grade)	25.00	45.00
Cellulose Diacetate-Clareflect metallized film	30.00	50.00
Cellulose Diacetate-Colored Films	25.00	45.00
Cellulose Diacetate-Flame retardant Film	20.00	40.00
Cellulose Diacetate-High Slip Film	25.00	40.00
Cellulose Diacetate-Semitone Films	20.00	45.00
CP - Cellulose Propionate	30.00	10.00
COC - Cyclic Olefin Copolymer	1.700	4.500
CPVC - Chlorinated Polyvinyl Chloride	23.00	50.00
ECTFE - Ethylene ChloroTriFluoroEthylene	250.00	325.00
ETFE - Ethylene Tetrafluoroethylene	100.00	300.00
EVA - Ethylene Vinyl Acetate	200.00	990.00
EVOH - Ethylene Vinyl Alcohol	180.00	350.00
FEP - Fluorinated Ethylene Propylene	250.00	300.00
HDPE - High Density Polyethylene	500.00	700.00

HIPS - High Impact Polystyrene	10.00	65.00
HIPS Flame Retardant V0	10.00	50.00
Ionomer (Ethylene-Methyl Acrylate Copolymer)	290.00	740.00
LCP - Liquid Crystal Polymer	1.00	3.00
LCP Carbon Fiber-reinforced	1.00	1.00
LCP Glass Fiber-reinforced	1.00	3.00
LCP Mineral-filled	2.00	5.50
LDPE - Low Density Polyethylene	200.00	600.00
LLDPE - Linear Low Density Polyethylene	300.00	900.00
MABS - Transparent Acrylonitrile Butadiene Styrene	12.00	20.00
PA 11 - (Polyamide 11) 30% Glass fiber reinforced	3.00	6.00
PA 11, Conductive	186.00	186.00
PA 11, Flexible	225.00	405.00
PA 11, Rigid	225.00	355.0
PA 12 (Polyamide 12), Conductive	186.00	186.00
PA 12, Fiber-reinforced	4.00	8.00
PA 12, Flexible	300.00	340.00
PA 12, Glass Filled	30.00	40.00
PA 12, Rigid	250.00	390.00
PA 46 - Polyamide 46	160.00	300.00
PA 46, 30% Glass Fiber	11.00	15.00
PA 6 - Polyamide 6	200.00	300.00
PA 6-10 - Polyamide 6-10	150.00	300.00
PA 66 - Polyamide 6-6	150.00	300.00

PA 66, 30% Glass Fiber	2.00	2.20
PA 66, 30% Mineral filled	2.00	45.00
PA 66, Impact Modified, 15-30% Glass Fiber	3.00	10.00
PA 66, Impact Modified	150.00	300.00
Polyamide 66 (Nylon 66), Long Glass Fiber, 40% Filler by Weight	2.00	2.00
Polyamide 66 (Nylon 66), Long Glass Fiber, 50% Filler by Weight	2.00	2.00
Polyamide 66 (Nylon 66), Long Glass Fiber, 60% Filler by Weight	2.00	2.00
Polyamide semi-aromatic	50.00	200.00
PAI - Polyamide-Imide	3.00	15.00
PAI, 30% Glass Fiber	6.00	7.00
PAI, Low Friction	7.00	9.00
PAN - Polyacrylonitrile	3.00	4.00
PAR - Polyarylate	50.00	100.00
PARA (Polyarylamide), 30-60% glass fiber	1.80	2.00
PBT - Polybutylene Terephthalate	5.00	300.00
PBT, 30% Glass Fiber	2.00	3.00
PC (Polycarbonate) 20-40% Glass Fiber	2.00	4.00
PC (Polycarbonate) 20-40% Glass Fiber Flame Retardant	2.00	4.00
PC - Polycarbonate, high heat	50.00	120.00
PC/PBT Blend - Polycarbonate/Polybutylene Terephthalate Blend	4.00	175.00
PC/PBT blend, Glass Filled	2.00	4.00

PCL - Polycaprolactone	600.00	900.00
PCTFE - Polymonochlorotrifluoroethylene	80.00	180.00
PE - Polyethylene 30% Glass Fiber	1.500	2.500
PE/TPS Blend - Polyethylene/Thermoplastic Starch	400.00	700.00
PEEK - Polyetheretherketone	30.00	150.00
PEEK 30% Carbon Fiber-reinforced	1.00	3.00
PEEK 30% Glass Fiber-reinforced	2.00	3.00
PEI - Polyetherimide	59.00	60.00
PEI, 30% Glass Fiber-reinforced	3.00	3.00
PEI, Mineral Filled	6.00	6.00
PEKK (Polyetherketoneketone), Low Cristallinity Grade	80.00	80.00
PESU - Polyethersulfone	10.00	80.00
PESU 10-30% glass fiber	2.00	6.00
PET - Polyethylene Terephthalate	30.00	70.00
PET, 30% Glass Fiber-reinforced	2.00	7.00
PET, 30/35% Glass Fiber-reinforced, Impact Modified	6.00	6.00
PETG - Polyethylene Terephthalate Glycol	50.00	50.00
PFA - Perfluoroalkoxy	300.00	300.00
PGA - Polyglycolides	15.00	20.00
PHB - Polyhydroxybutyrate	3.00	6.00
PHB-V (5% valerate)	5.00	10.00
PI - Polyimide	90.00	90.00
PLA - Polylactide	5.00	7.00

PLA, High Heat Films	179.00	181.00
PLA,injection molding	2.00	3.00
PMMA - Polymethylmethacrylate/Acrylic	2.00	10.00
PMMA (Acrylic) High Heat	2.00	10.00
PMMA (Acrylic) Impact Modified	4.00	70.00
PMP - Polymethylpentene	7.50	30.00
PMP 30% Glass Fiber-reinforced	2.00	3.00
PMP Mineral Filled	20.00	30.00
POM - Polyoxymethylene (Acetal)	15.00	75.00
POM (Acetal) Impact Modified	60.00	200.00
POM (Acetal) Low Friction	10.00	70.00
POM (Acetal) Mineral Filled	5.00	55.00
PP - Polypropylene 10-20% Glass Fiber	3.00	4.00
PP, 10-40% Mineral Filled	30.00	50.00
PP, 10-40% Talc Filled	20.00	30.00
PP, 30-40% Glass Fiber-reinforced	2.00	3.00
PP (Polypropylene) Copolymer	200.00	500.00
PP (Polypropylene) Homopolymer	150.00	60.00
PP Homopolymer, Long Glass Fiber, 30% Filler by Weight	2.00	2.00
PP Homopolymer, Long Glass Fiber, 40% Filler by Weight	2.00	2.00
PP Homopolymer, Long Glass Fiber, 50% Filler by Weight	2.00	2.00
PP, Impact Modified	200.00	700.00
PPA - Polyphthalamide	2.60	30.00

PPA – 30% Mineral-filled	1.10	1.30
PPA, 33% Glass Fiber-reinforced	2.00	2.20
PPA, 33% Glass Fiber-reinforced – High Flow	1.70	1.90
PPA, 45% Glass Fiber-reinforced	227.00	229.00
PPE - Polyphenylene Ether	45.00	60.00
PPE, 30% Glass Fiber-reinforced	3.00	3.00
PPE, Flame Retardant	30.00	50.00
PPE, Impact Modified	40.00	60.00
PPE, Mineral Filled	20.00	40.00
PPS - Polyphenylene Sulfide	1.00	4.00
PPS, 20-30% Glass Fiber-reinforced	1.00	2.00
PPS, 40% Glass Fiber-reinforced	1.00	2.00
PPS, Conductive	0.50	3.00
PPS, Glass fiber & Mineral-filled	1.000	3.00
PPSU - Polyphenylene Sulfone	30.00	90.00
PS (Polystyrene) 30% glass fiber	1.00	1.50
PS (Polystyrene) Crystal	1.00	4.00
PS, High Heat	1.00	4.00
PSU - Polysulfone	50.00	100.00
PSU, 30% Glass fiber-reinforced	2.00	3.00
PSU Mineral Filled	2.00	5.00
PTFE - Polytetrafluoroethylene	200.00	400.00
PTFE, 25% Glass Fiber-reinforced	100.00	300.00
PVC (Polyvinyl Chloride), 20% Glass Fiber-reinforced	2.00	5.00

PVC, Plasticized	100.00	400.00
PVC, Plasticized Filled	200.00	500.00
PVC Rigid	25.00	80.00
PVDC - Polyvinylidene Chloride	160.00	250.00
PVDF - Polyvinylidene Fluoride	50.00	300.00
SAN - Styrene Acrylonitrile	2.00	5.00
SAN, 20% Glass Fiber-reinforced	1.00	2.00
SMA - Styrene Maleic Anhydride	2.00	30.00
SMA, 20% Glass Fiber-reinforced	2.00	3.00
SMA, Flame Retardant V0	2.00	2.00
SMMA - Styrene Methyl Methacrylate	2.10	52.00
SRP - Self-reinforced Polyphenylene	6.00	10.00
TPS/PE BLend - Thermoplastic Starch/ Polyethylene Blend (30 micron films tested)	300.00	350.00
TPS, Injection General Purpose	25.00	135.00
TPS, Water Resistant	2.00	2.00
UHMWPE - Ultra High Molecular Weight Polyethylene	200.00	500.00
XLPE - Crosslinked Polyethylene	10.00	440.00